

Investigation of Electrical Properties of Pure and Thallium Chloride Doped Poly Vinyl Alcohol Polymer Electrolyte Films

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ABSTRACT

Poly Vinyl Alcohol is a water-soluble amorphous/crystalline polymer that is widely used in protective coating, biomedical and optical materials, orbents and membranes. In the present investigation, an attempt has been made to characterize the polymer electrolytes based on Poly vinyl alcohol substituted with thallium chloride at different weight percentage ratio. Solid polymer electrolyte films based on poly vinyl alcohol doped with Thallium Chloride (TlCl) were prepared using solution cast technique. In the present communication, we studied the Conductivity variation with the concentration of Thallium Chloride (TlCl) in Poly Vinyl Alcohol and Conductivity variation with the temperature in Thallium Chloride (TlCl) substituted Poly Vinyl Alcohol.

.Keywords - **Poly Vinyl Alcohol, Solid polymer electrolyte films, Conductivity variation, Thallium Chloride (TlCl)**

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I. INTRODUCTION

Polymers are widely used in electrical and electronic applications. Initially most of the polymers were used as insulators because of their high resistivity and dielectric properties. Polymer-based insulators are used in electrical equipment to separate electrical conductors without passing current through themselves. The applications of polymers as insulators include printed circuit boards, wire encapsulants, corrosion protective electronic devices, and cable sheathing materials etc.,[1] Polymer films have several advantages, such as easy processing, low cost, flexibility, high strength, and good mechanical properties. In the microelectronic fabrication industry, polymers are used in the photolithography process. The reports of electrical conductivity in ionic polymers in 1975 by Wright [2] and Shirakawa et al. [3] in 1977 on the synthesis of electrically conducting organic polymers have attracted the interest of thousands of academic and industrial researchers.

The possibility of combining in these new materials the properties of organic polymers and the electronic properties of semiconductors has been the driving force for various applications. The discovery of conducting polymers opened up many new possibilities for devices combining unique optical, electrical, and mechanical properties. Macdiarmid [4], and Heeger [5] found that the conducting polymer polyacetylene can be used as a dopant and change the conductivity of the doped material. To enhance the conductivity using polymers as well as to create new optical and electrical properties of

polymer, four doping processes namely, chemical doping, photochemical doping, electrochemical doping, and interfacial doping have been used [4,5]. Polymer materials have also been mixed with other salts or hybridized with other inorganic/nanoparticle materials to modify the optical and electrical properties of the polymer system. All these will affect the electrical properties of polymers.

In recent years several ionically conducting polymers or polymer electrolytes have been prepared for a wide range of applications ranging from rechargeable batteries to smart windows. Polymer electrolytes are also highly processable. Electrical conduction in polymers has been extensively studied in recent years to understand the nature of charge transport in these materials [6,7]. Various conduction mechanisms such as Schottky effect, the Pool-frenkel effect, space charge limited conduction and hopping conduction [8] have been suggested for the charge transport. The electrical conductivity of polymers not only depends on the thermally generated carriers but also on the addition of suitable dopants [9,10]. Although charge transport in polymers is a problem with great technological implication, the current understanding of the elemental processes involved is still unsatisfactory [11].

In the present work an attempt has been made to study the electrical transport properties of pure PVA films and doped films of PVA with Thallium Chloride (TlCl).

II. MATERIALS AND METHOD

Films of pure PVA and various compositions of complexed films of PVA with TlCl salt were prepared in weight percent ratios (80:20), (60:40) and (40:60) by solution cast technique using double distilled water as solvent. The detailed Preparation technique of the samples were published in our previous communication [12].

III. RESULTS AND DISCUSSION

(a) variation of Conductivity with the concentration of TlCl in PVA:

The DC electrical conductivity of the samples with different TlCl concentrations is shown in Fig. (1). From the figure it is clear that the conductivity of PVA increases up to 20wt% of dopant concentration and suddenly jumps at 40wt% then attains maximum at 60wt%.

The variations of conductivity are attributed to the formation of charge transfer complexes with in PVA matrix due to doping. It is known that in semicrystalline polymers, the dopant forms charge transfer complexes and is expected to reduce the barrier between the trapping sites.

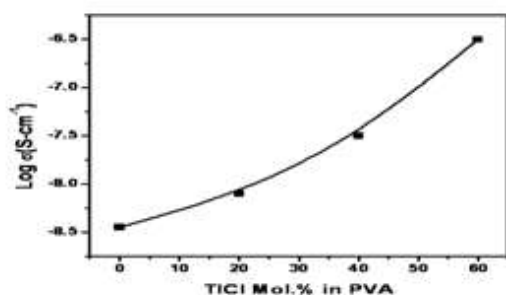


Fig (1) DC electrical conductivity of the samples with different TlCl concentrations

The motion of charged carriers in solid polymer is a liquid-like mechanism by which the movement of Ions through the polymer matrix is assisted by the large amplitude of the polymer segment motion [13]. The segmental mobility of Polymer chains is much higher in amorphous regions than in crystalline. In general, the conductivity increases as the degree of crystallinity decreases. The continuous increase in conductivity with the increase in TlCl percentage is attributed to the decrease in the degree of crystallinity.

(b) Conductivity variation with temperature in PVA +TlCl system

Fig (2) shows that the conductivity is increasing with increasing temperature in pure PVA as well as the compositions of polymer electrolytes.

The increase in the conductivity with temperature may be attributed to the transitions from

crystalline/semi-crystalline phase to amorphous phase. The increase in conductivity with temperature is interpreted in terms of hopping mechanism between coordination sites, local structural relaxation and segmental motion of the polymer. As amorphous region increase, the polymer chain acquires faster internal modes in which the bond rotations produce segmental motion.

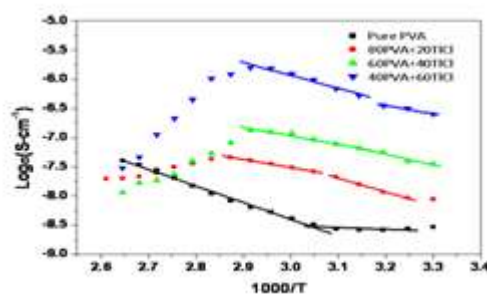


Fig (2) :Variation of conductivity with Temperature for pure PVA and Thallium Chloride doped (PVA+TlCl) composite films

This in turn, favors hopping inter chain and intra chain ion movements and the conductivity of the polymer thus becomes high. The activation energies calculated from slopes of log (σ) vs. 1/T plots, for both the regions. The activation energies decreased with the increase of the salt concentration initially and then increased for higher concentration of TlCl. The decrease with addition of salt as explained above could be due to formation of charge transfer complexes in the host lattice.

IV. CONCLUSION

The DC electrical conductivity of PVA+TlCl increases up to 20Wt% of dopant concentration and suddenly jumps at 40wt%, then attains maximum at 60wt%. The variation of conductivity is attributed to the formation of charge transfer complexes with in PVA matrix due to doping. The segmental mobility of Polymer chains is much higher in amorphous regions than in crystalline. In general, the conductivity increases as the degree of crystallinity decreases. The continuous increase in conductivity with the increase in TlCl percentage is attributed to the decrease in the degree of crystallinity.

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